Mechanical Behavior of Electrodeposited Copper Film at Elevated Temperatures

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University of Colorado

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Summary:

- Tensile behavior measured for 2.6 μm thick electrodeposited Cu, room temperature to 150 ºC
- Modulus values results low, but uncertainty high in this technique
- Strengths 200-300 MPa
- Low tensile ductility
- Temperature dependence of strengths moderate, in the expected direction
- Strain rate effects moderate to minimal in the range tested
- Fracture surfaces showed chisel-point fractures, ligaments, suggestive of high local ductility
- Rapid formation of unknown corrosion layer masked subtle metallographic features on the fracture surfaces

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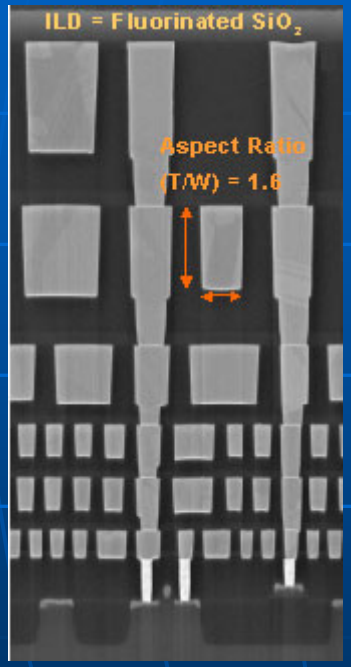
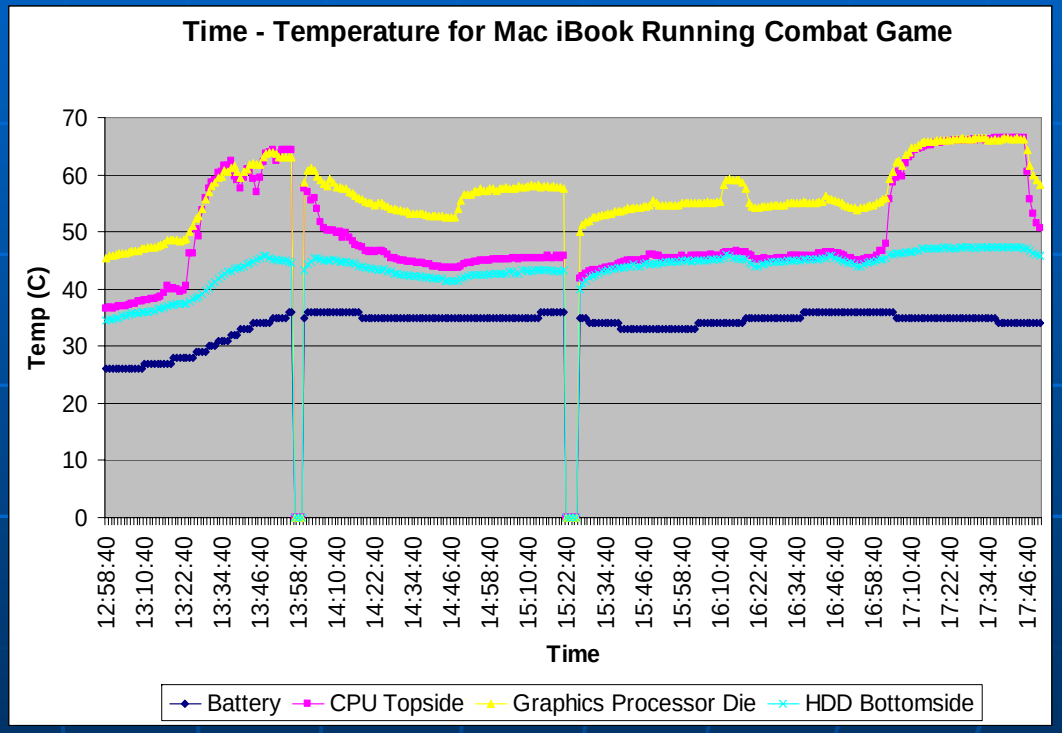
Motivation:

Data for design of electronic interconnects





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Material:

Electrodeposited copper

Seed:

thermally evaporated;

60 nm thick on bare silicon

Solution:

Conventional acid-based,

with brightener

Thickness:

2.6 µm

Grain size:

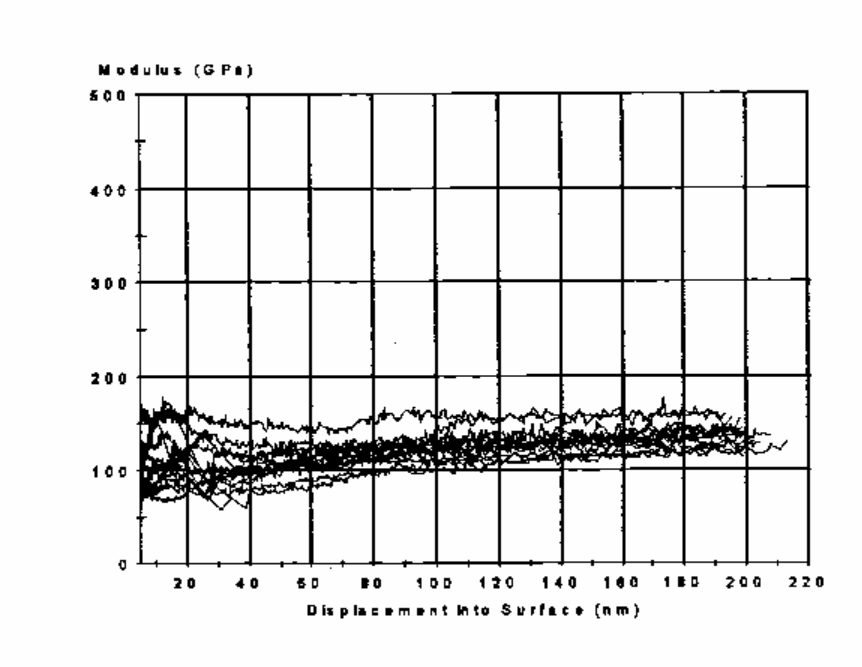
>~ 1 µm (EBSD)

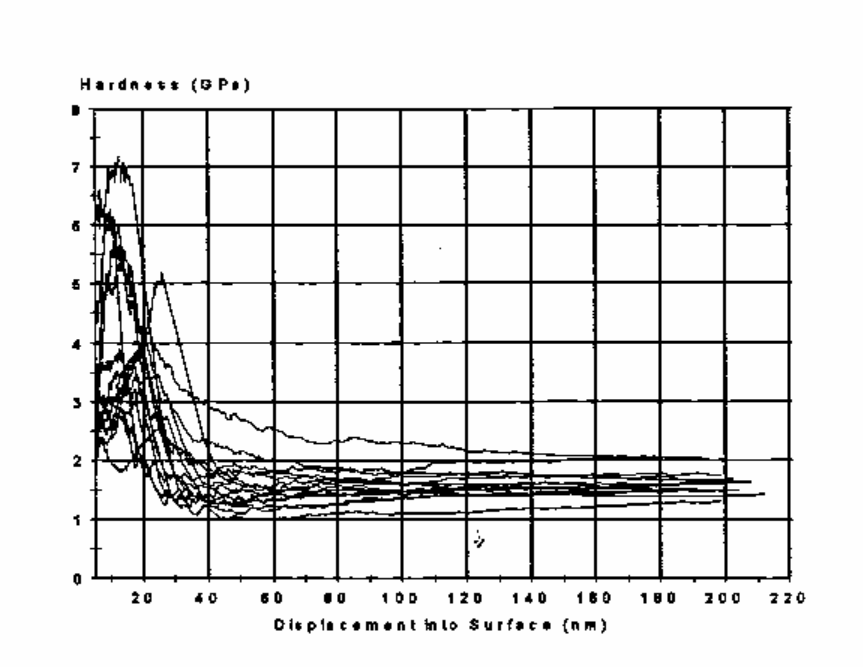
Texture:

Film plane normal is <111>

Material, continued:

Commercial high-precision nanoindentation instrument:

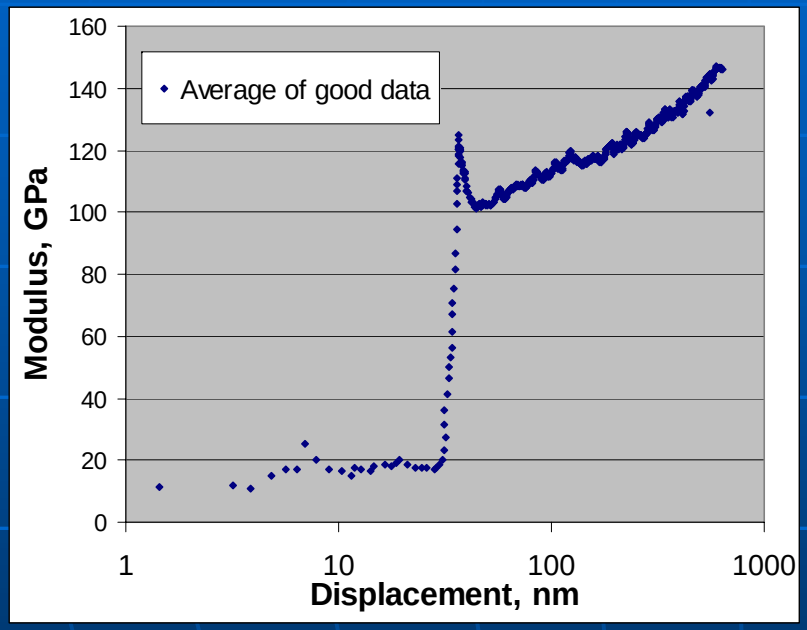


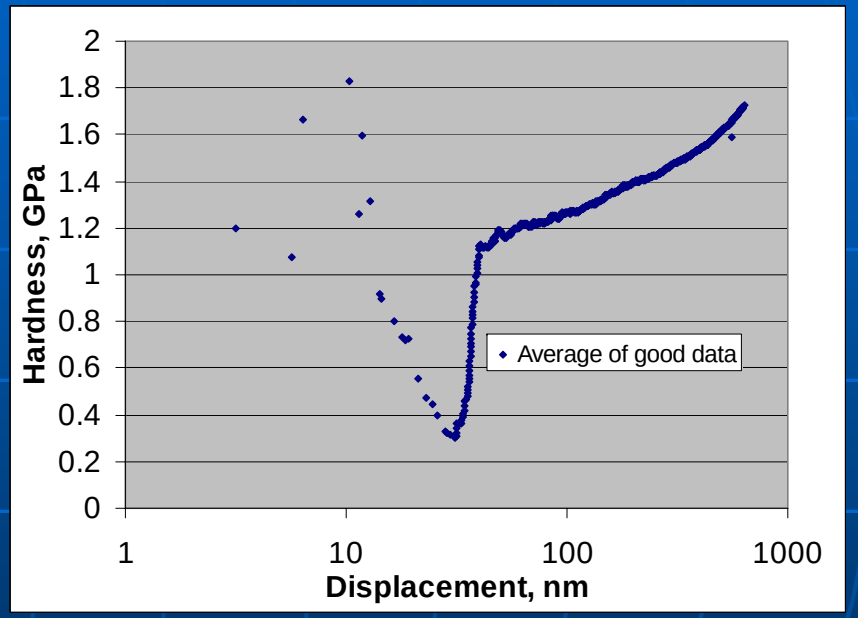


Modulus: 125±9 GPa, Hardness: 1.54±0.11 GPa

Material, continued:

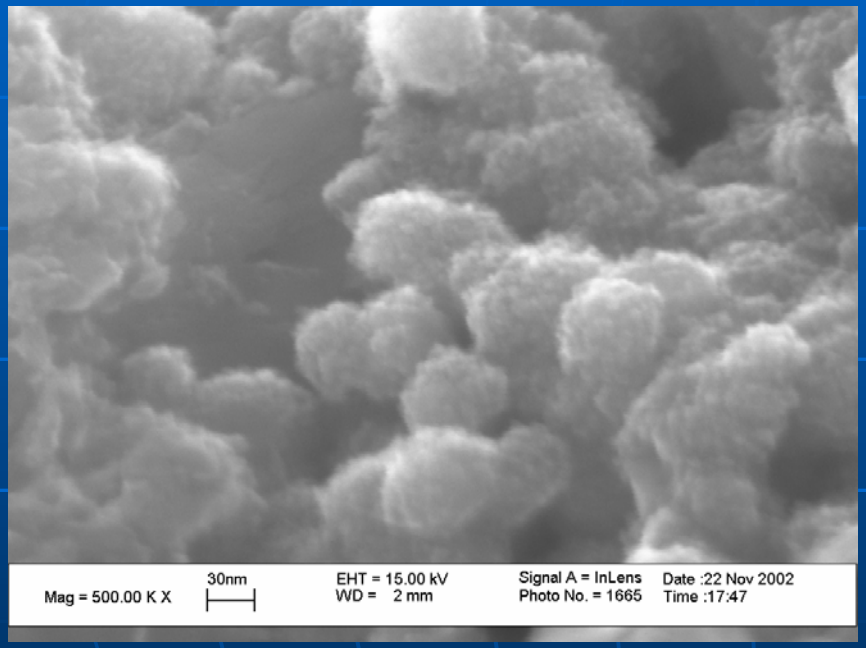
Commercial nanoindentation instrument (aged):

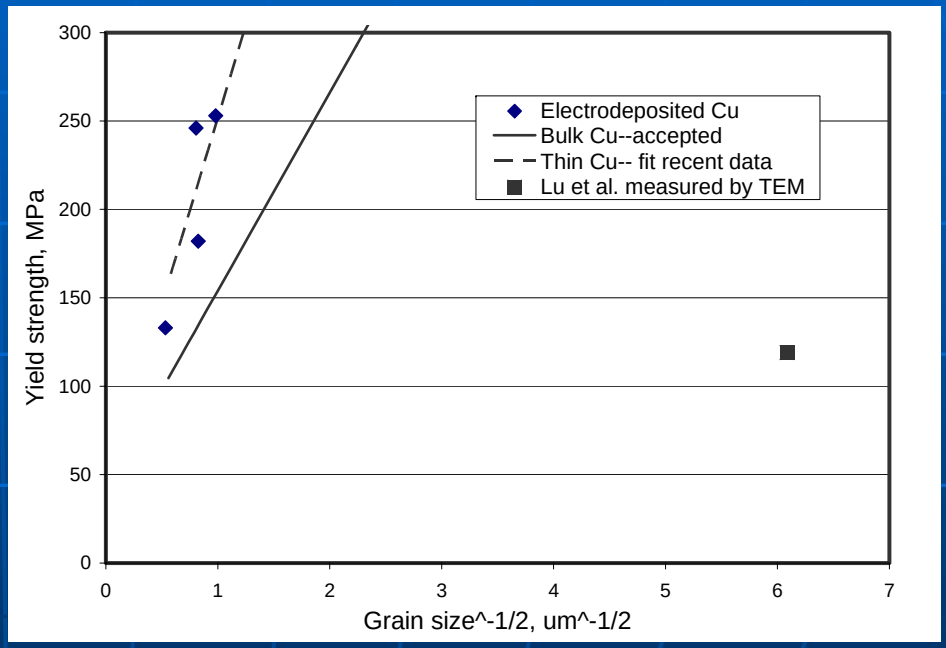




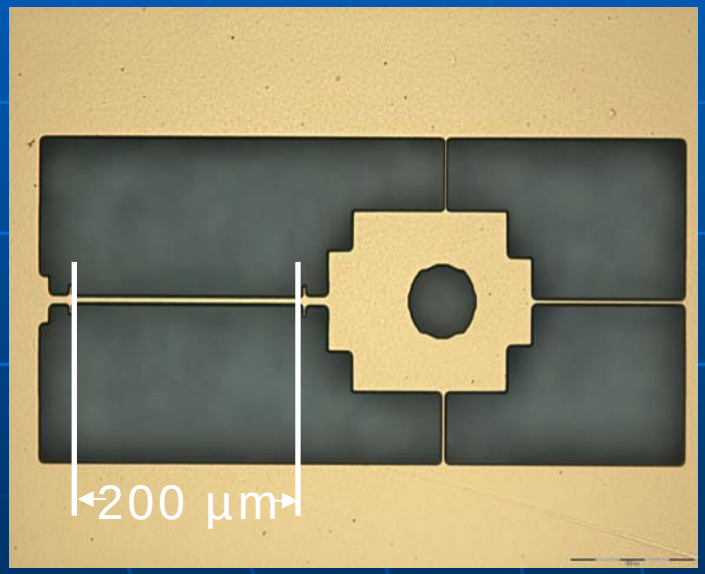
Modulus: 122±6 GPa, Hardness: 1.40±0.08 GPa

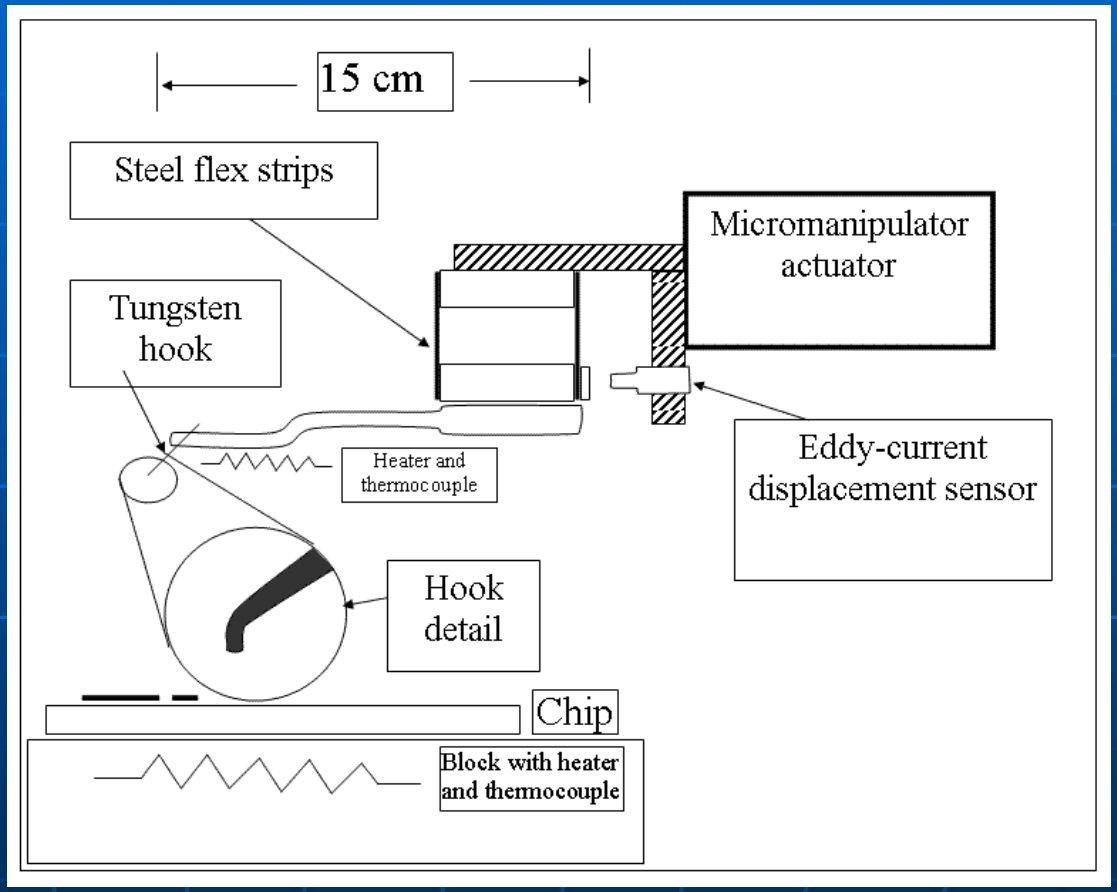
Material, continued:





Method: Microtensile testing

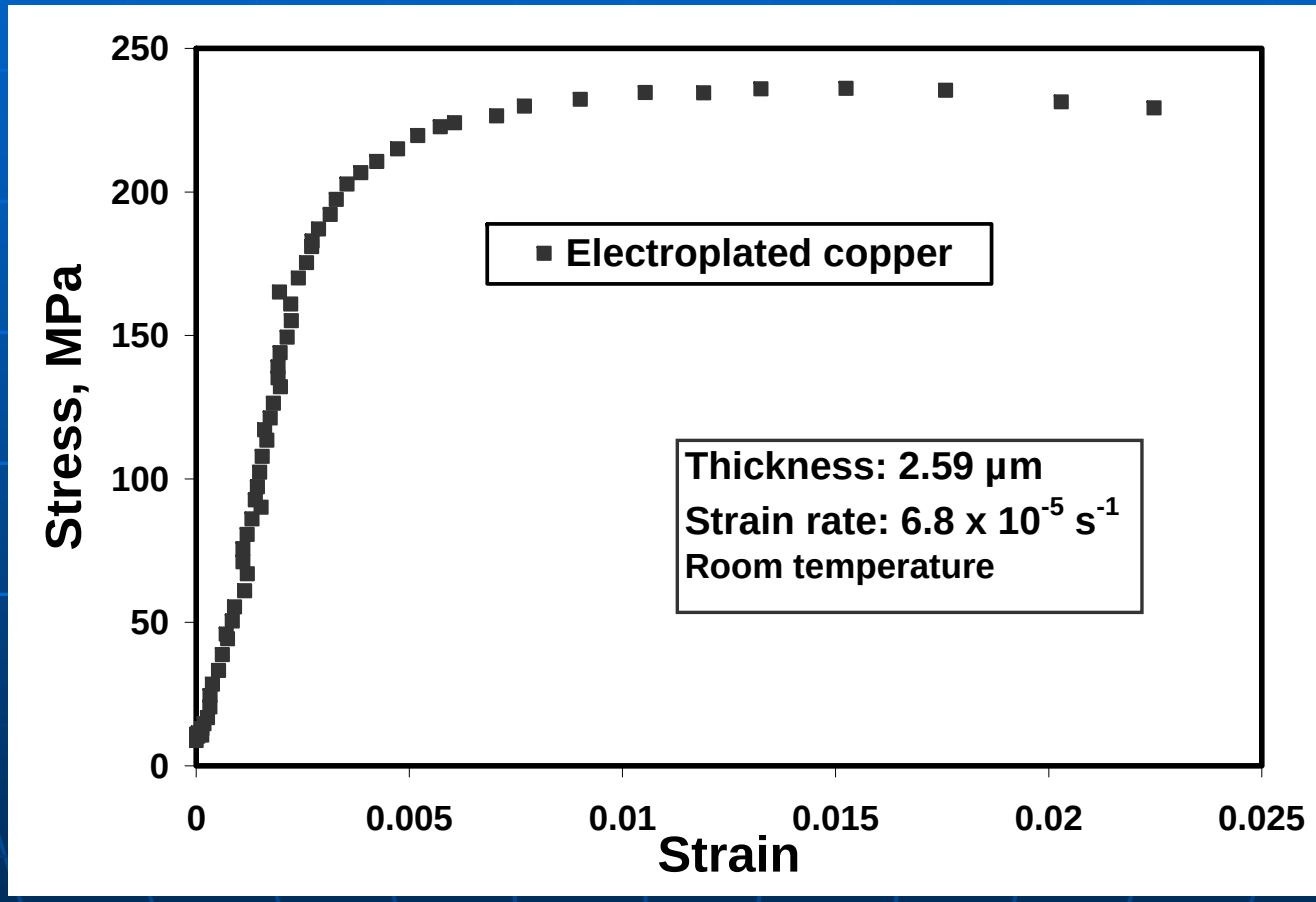




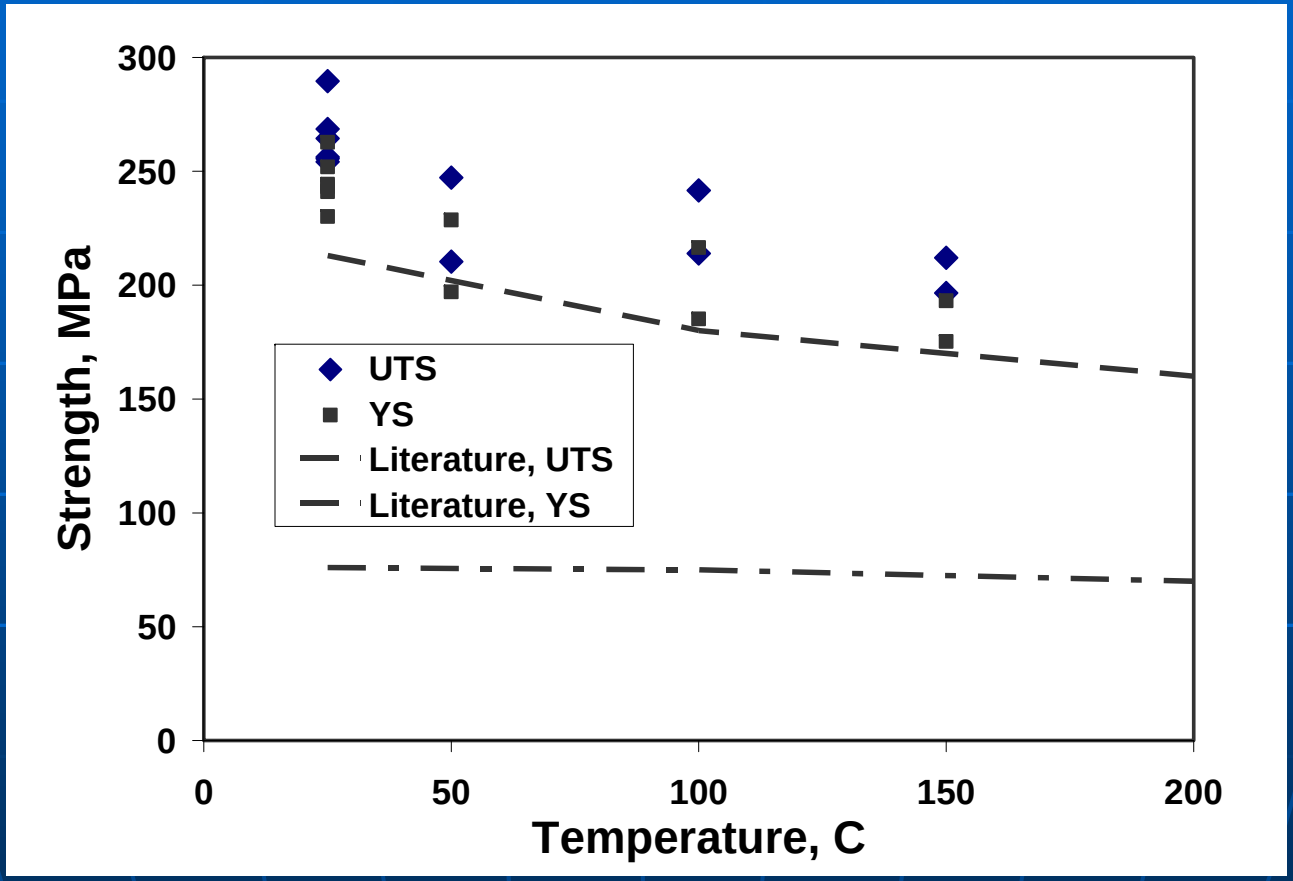
Method, continued:

Force:	Calibrated spring on force probe
Displacement:	Digital image correlation
Specimen dimensions:	Profilometer, optical microscope
Temperature:	Thermocouples beneath chip and on pull rod

Results: Stress-strain curves



Results: Temperature dependence



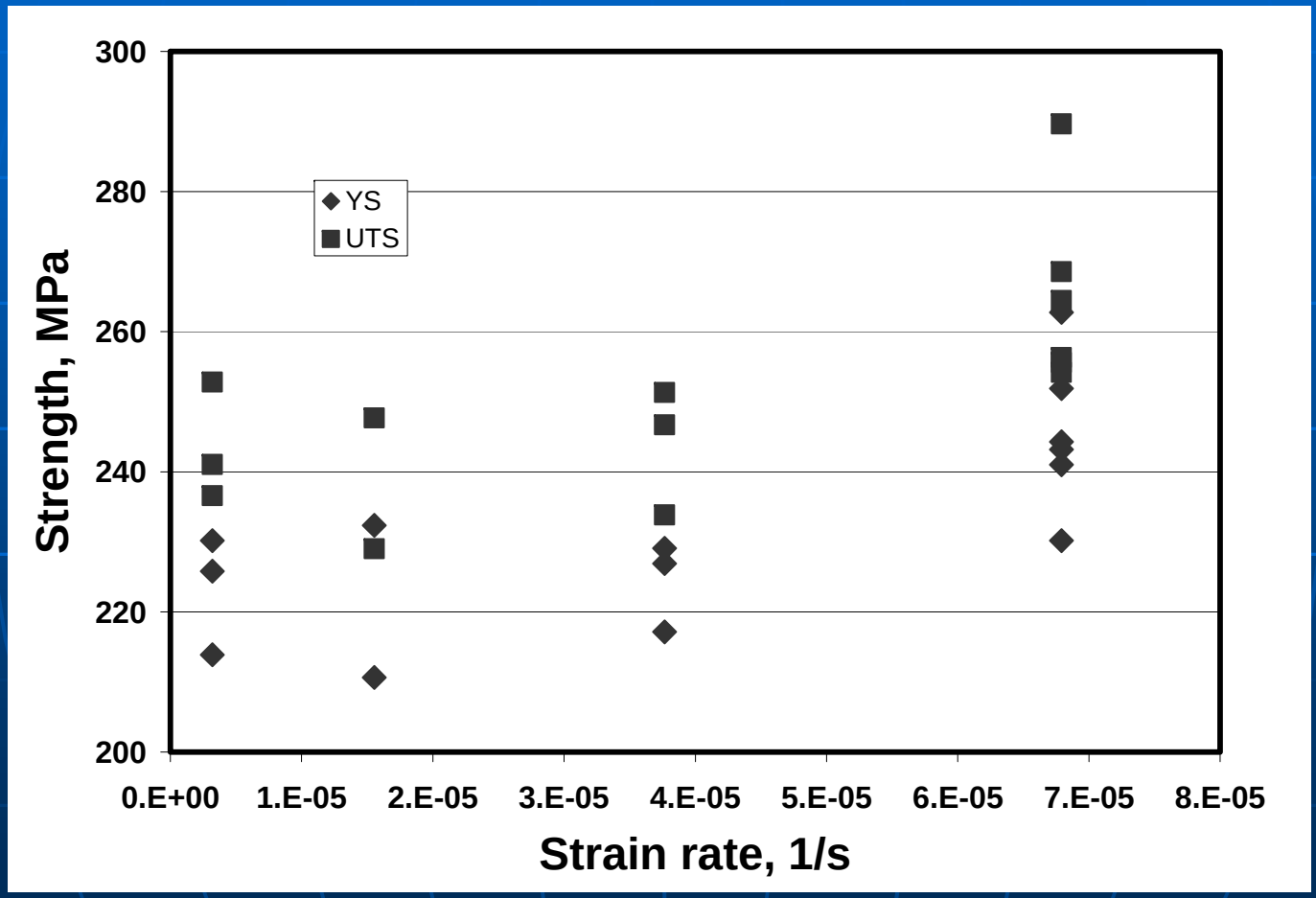
Literature: Carreker and Hibbard, *Acta Metallurgica* **1** 654-663, 1953

Results:

- Moderate temperature dependence;
- High strength vs pure annealed bulk;
- Low tensile elongation to failure;
- High variability of Young's modulus, E

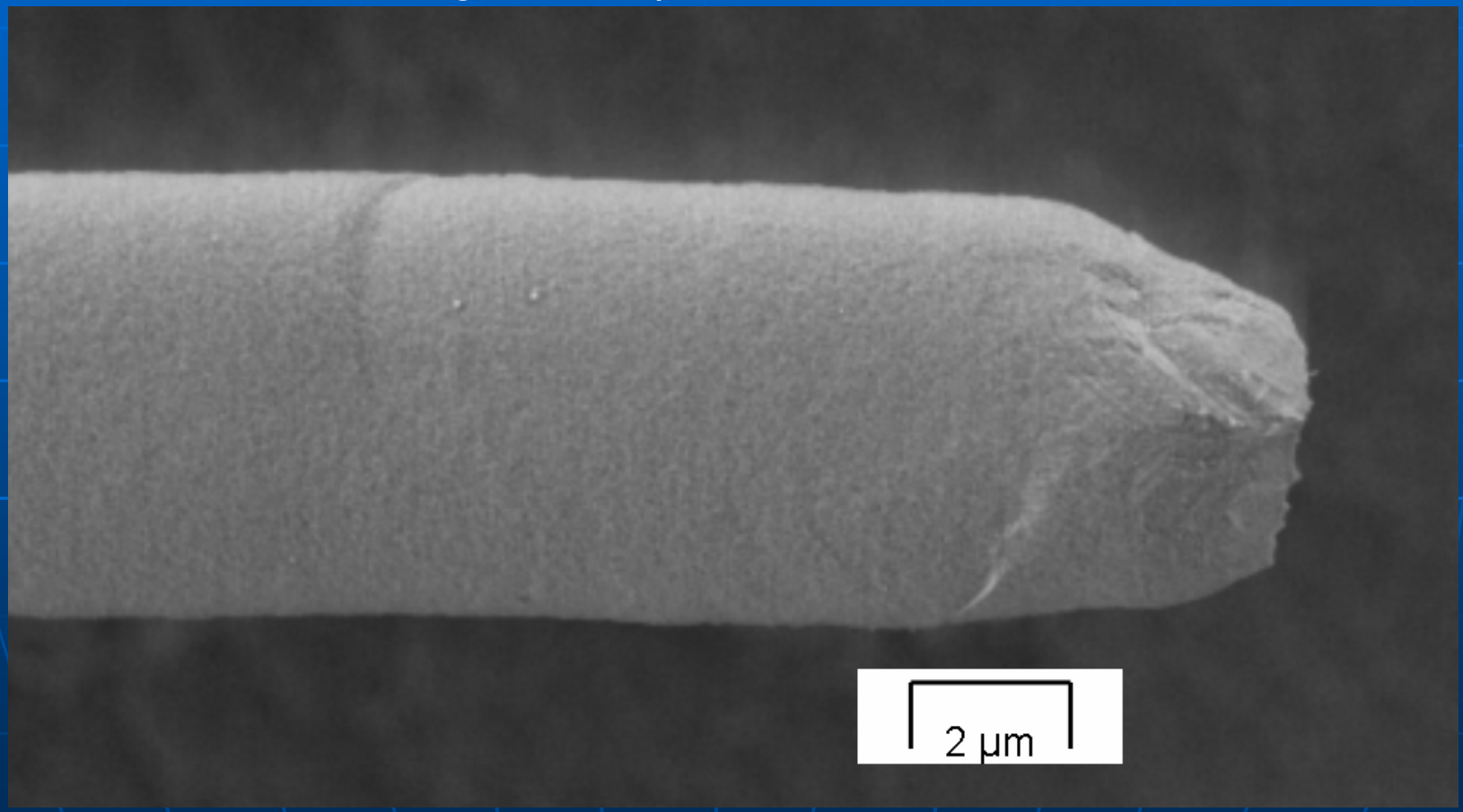
Temp., C	Number of tests	YS, MPa	UTS, MPa	E, GPa	Elong., %
25	18	234±16	257±17	72±22	2.2±0.7
50	2	213±22	229±26	NA	1.5±0.2
100	2	201±22	228±20	82±3	1.7±0.07
150	3	184±13	204±11	82±24	2.2±1.1

Results: Strain rate effect on strength at room temperature is moderate to minimal



Results: Fractography (1), top view

>>>> local necking; chisel-point failure



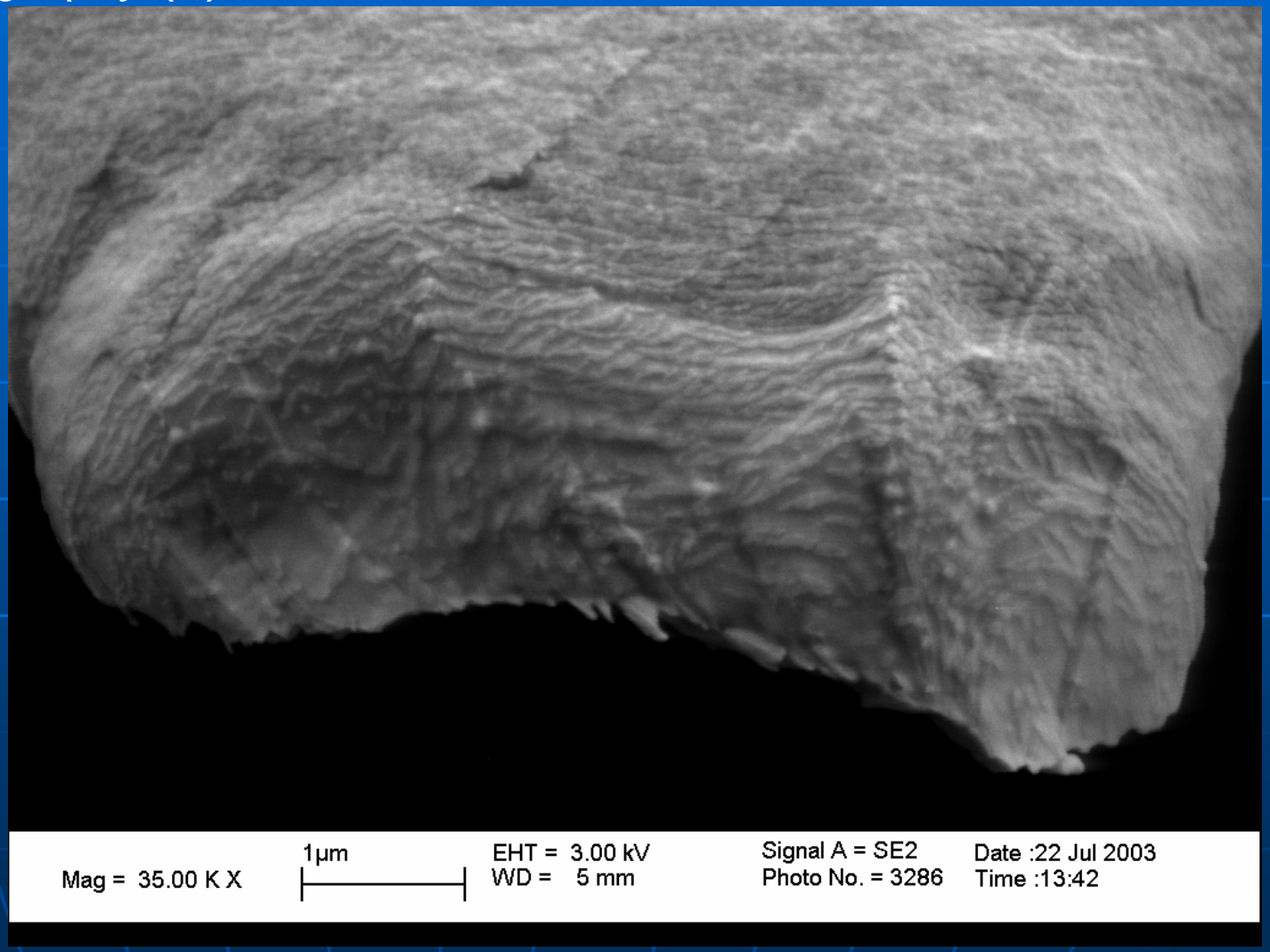
Results: Fractography (2), end view

Strange surface features—

metallographic,

??????????????

or reptilian?



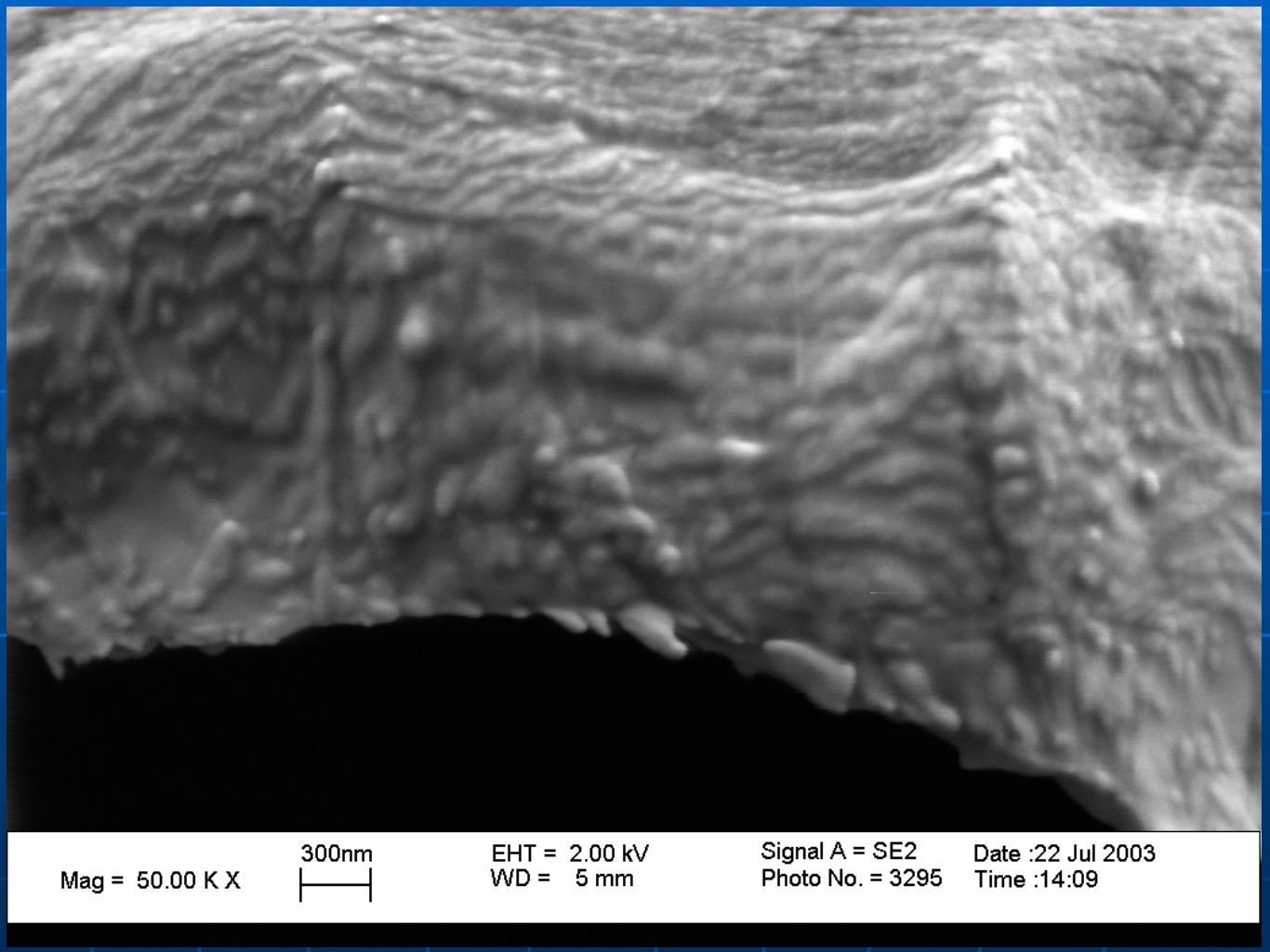
Results: Fractography (3), end view

Strange surface features—

metallographic,

??????????????

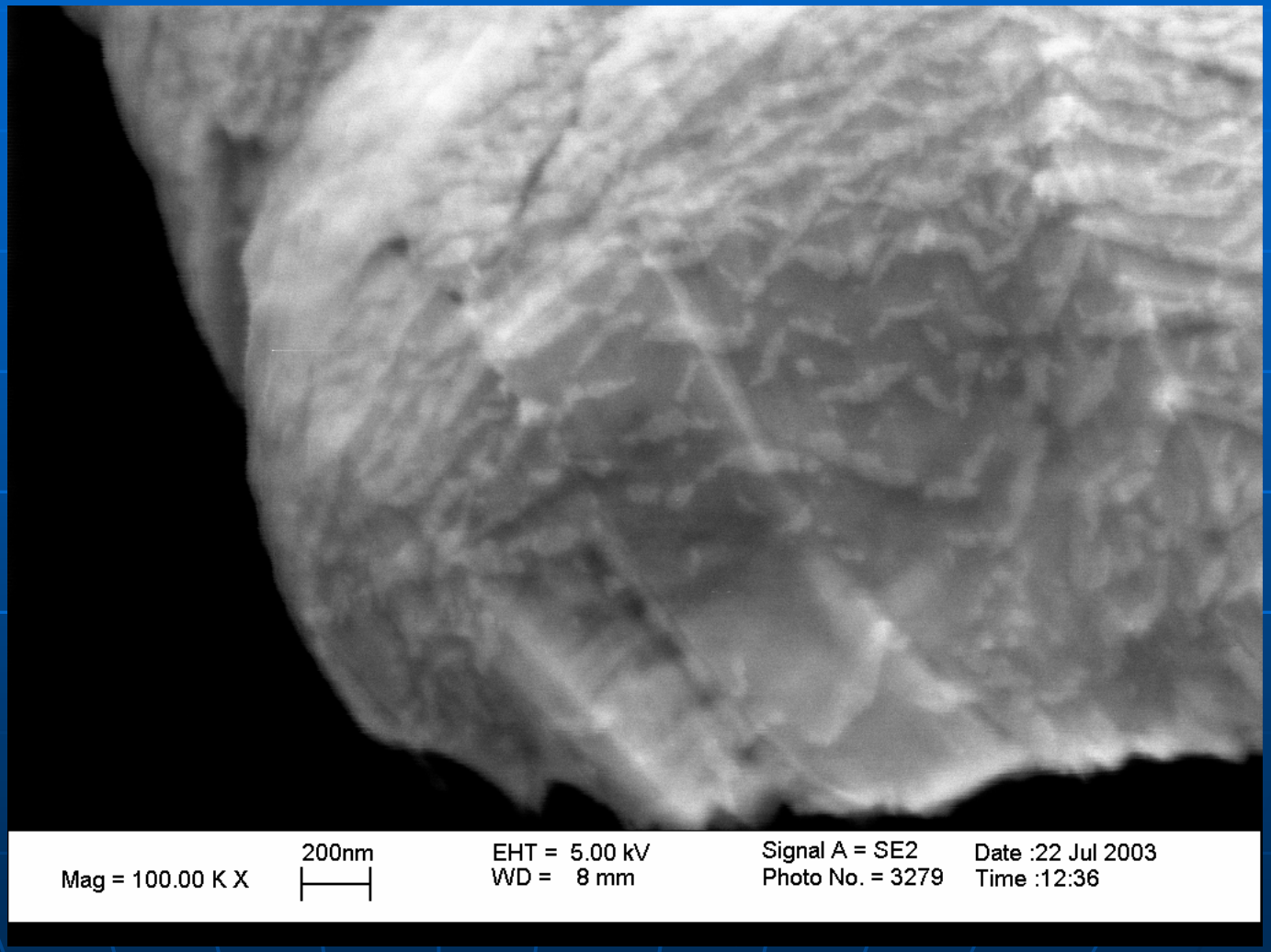
or reptilian?



Results: Fractography (4), end view

Strange surface features—

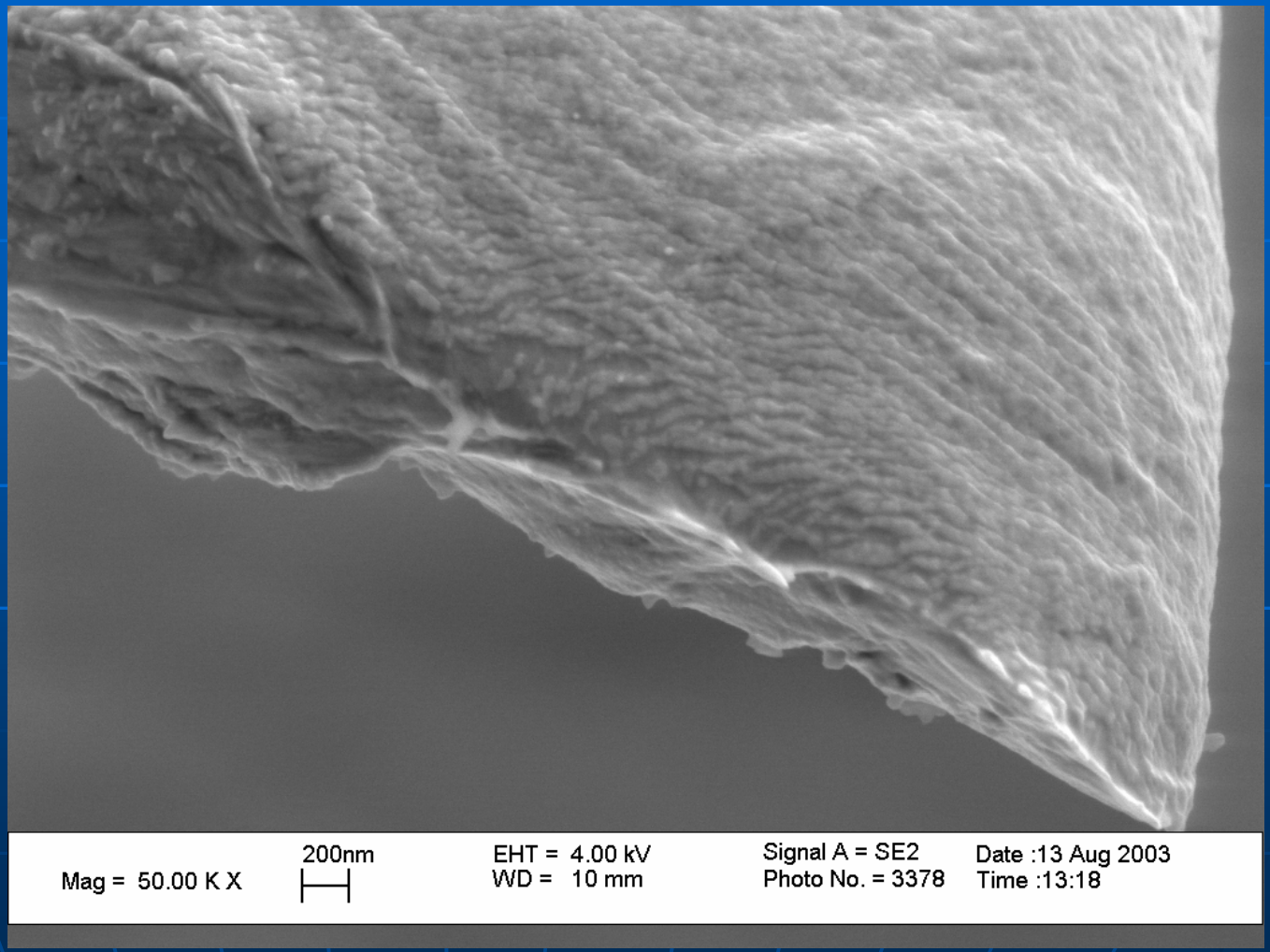
Mud cracks?



Results: Fractography, end view: (6)

Strange surface features—

Mud cracks?



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